Real-Time Distributed Communication

Open Systems Project Engineering Conference (OSPEC)

FY 98 Status Review

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OUTLINE

- Project Description/Tasks
- Goals/Pay-off/Impact
- Key Results
- Schedules
- Issues
- Recommendations
- Question & Answers

PROJECT DESCRIPTION/TASKS

PROBLEM DESCRIPTION:

- Embedded Systems unaffordable because:
  - Proprietary systems limit potential sources and do not leverage industry-funded advances
  - Application software not isolated from underlying hardware
- Result is expensive development, production, and support

APPROACH:

- Develop a standardized interface for real-time distributed communications facilities to :
  - Enable application portability at the source-code level
  - Allow commercial vendors to build open systems components
  - Provide infrastructure to support software interoperability between DoD systems
- Result is more affordable systems

APPLICATIONS:

- Joint Strike Fighter
- Aegis Combat System
- Cooperative Engagement Capability

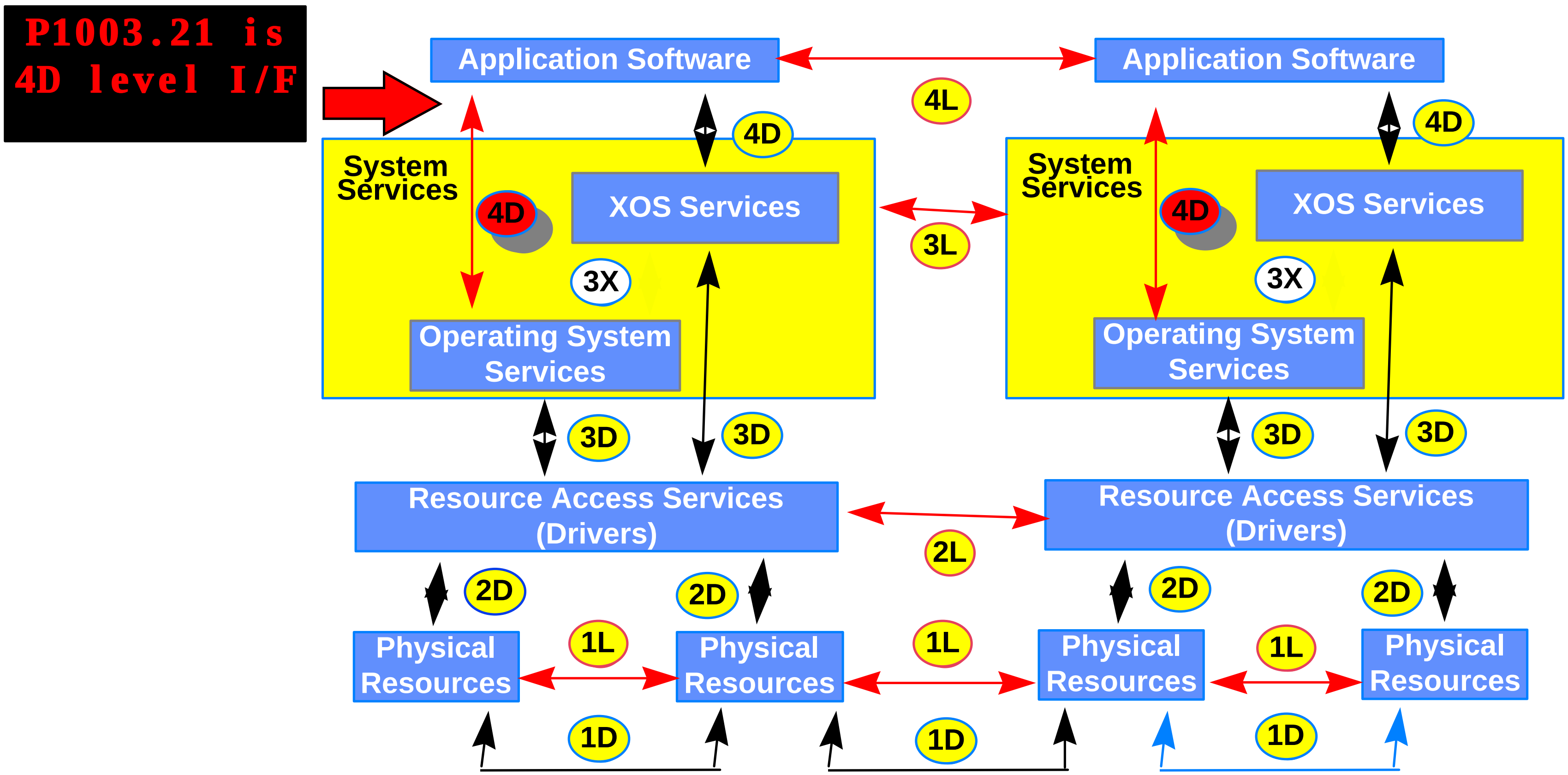
TASKS:

- Attain approval of 1003.21 Standard
- Update prototype's APIs for consistency with standard
- Extend Raytheon prototype to include more P1003.21 functionality

The GOA Framework

- **The Generic Open Architecture (GOA) Framework helps pinpoint critical system interfaces**
  - **Allows system components to evolve independently**
  - **Increases portability, reuseability of all components of system**
  - **Interfaces include Application Program Interface (API) as well as hardware layer**
  - **Defined by the Society of Automotive Engineers (SAE) Avionics Systems-5 working group**
- **The GOA Framework is incorporated in the Weapons Systems Emerging Standard section of the JTA**
- **POSIX Real-Time Distributed Systems Communication P1003.21 is a 4D level interface**

P1003.21 and GOA



4L Applications Logical Peer IFs
4D Applications-to-System Services Direct IFs
3L System Services Logical Peer IFs
3D Sys. Services SW-to-Resource Access Services Direct IFs
3X OS Services-to-XOS Services Direct IFs

2L Resource Access Services Logical Peer IFs
2D Resource Access Serv.-to-Phys. Resources Direct IFs
1L Physical Resources Logical Peer IFs
1D Physical Resources-to-Physical Resources Direct IFs

GOALS/PAY-OFFS/IMPACT

Goals of P1003.21:

- Provide a standard API for distributed systems communication which supports a wide range of real-time applications
  - Incorporation of real-time features, such as message priorities, buffer management, and asynchronous interactions
  - Incorporation of communications models beyond P1003.1g (Protocol Independent Interfaces - sockets), including unicast, multicast, broadcast, and labeled messages
  - Ability to utilize faster and better protocols as they are developed without affecting application source code
- Involvement from government, industry, and academia

GOALS/PAY-OFFS/IMPACT

Pay-offs/Impact of P1003.21:

- **Increased portability of application software**
- **P1003.21 provides infrastructure for interoperability**
  - **Applications can define structure of messages (4L)**
- **Potential infrastructure for real-time distributed objects**
  - **Distributed Object Technology (Common Object Request Broker Architecture - CORBA)**
- **Reduced cost of DoD distributed systems (due to increased software reuse)**
- **Meets needs of real-time community**
- **Versatile design models for message-passing systems**

KEY RESULTS

Project Participants Have:

- Provided an estimated 6 man years of support to the development of the 1003.21 standard.
- Prototyped and demonstrated subsets of the IEEE 1003.21 POSIX API in both Ada and C
- Shown feasibility and quantified overhead of using standard POSIX API vs. Raytheon proprietary API
- Developed and made public a web-based tool used for ballot resolution
  (http://www.sei.cmu.edu/technology/dynamic_systems/standards/posix.21.html)
- Developed a draft Real-time Avionics Profile (RAP) of POSIX standards

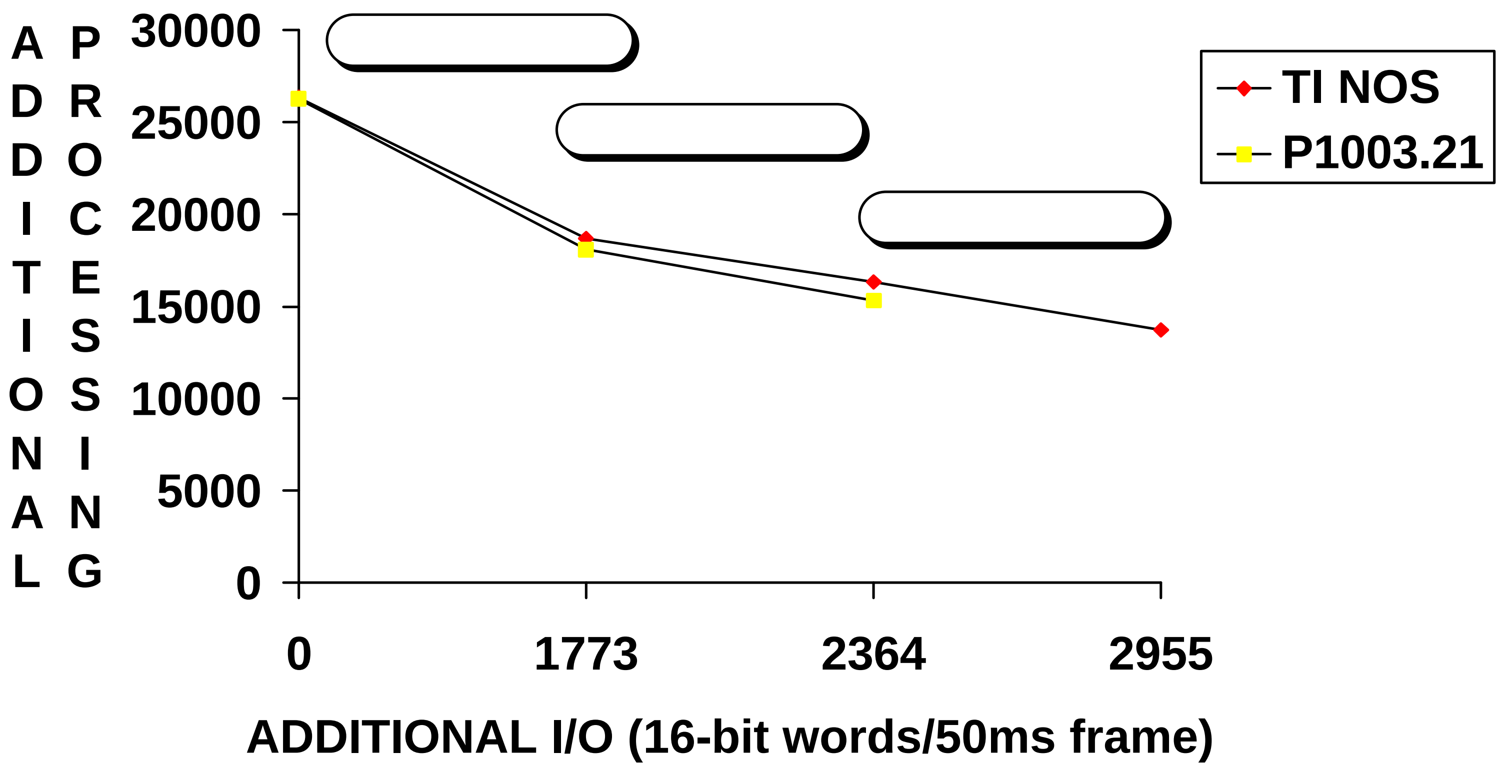
IMPLEMENTATIONS

- **Three different prototypes have been developed:**
  - **Ada implementation for MIL-STD-1750A processors communication over Pibus**
    - **Quantified overhead costs of P1003.21 (<7% add'l overhead)**
    - **Implemented using a proprietary OS**
  - **C Implementation for Sun workstations communicating over Ethernet**
    - **Implemented using COTS OS (Solaris/SunOS/HP-UX/IRIX/Linux)**
  - **C implementation for COTS processors (PowerPC) communicating over Compact PCI and Fibrechannel**
    - **Implemented using COTS OS (VxWorks)**

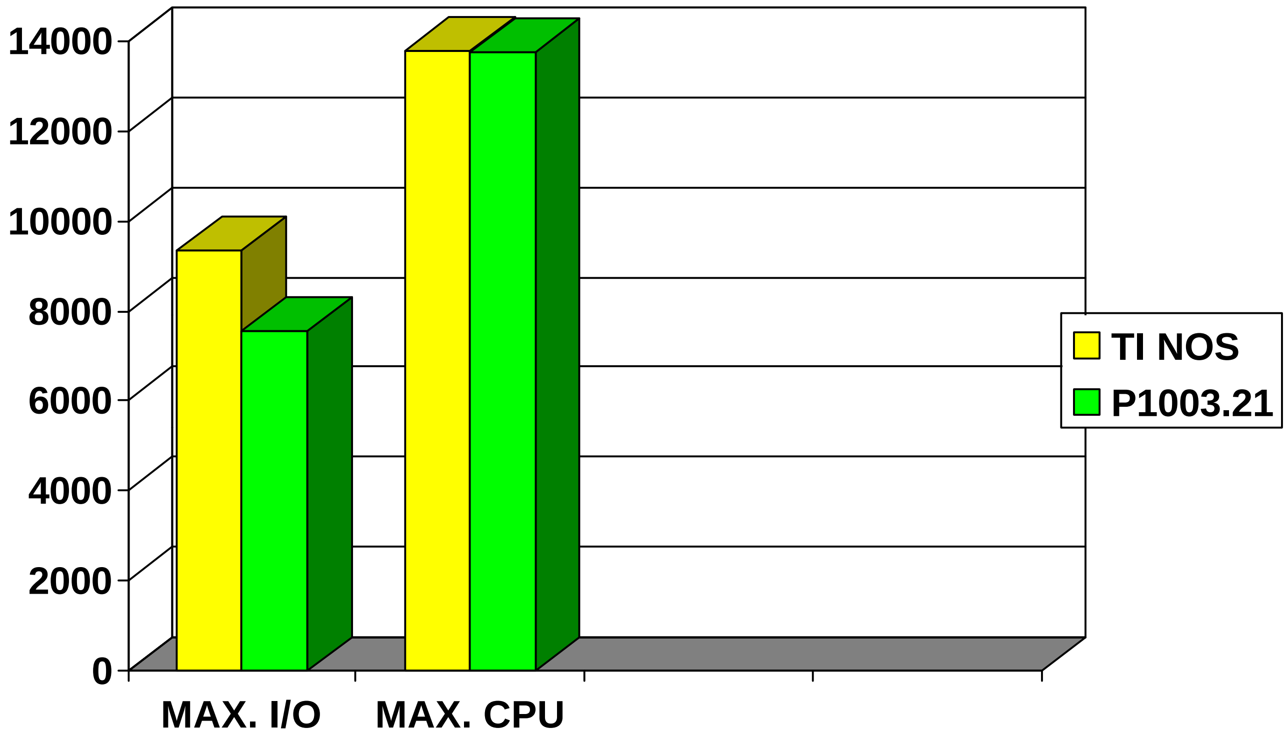
IMPLEMENTATIONS

- Lockheed Martin's Coms-X® provides C P1003.21 interface
  - Ada interface has not been released
  - Network support includes Ethernet, FDDI, ATM and proprietary protocols
  - Hosted on Solaris/SunOS/HP-UX

EMBEDDED COMPUTER PERFORMANCE MEASUREMENT (ECPM)

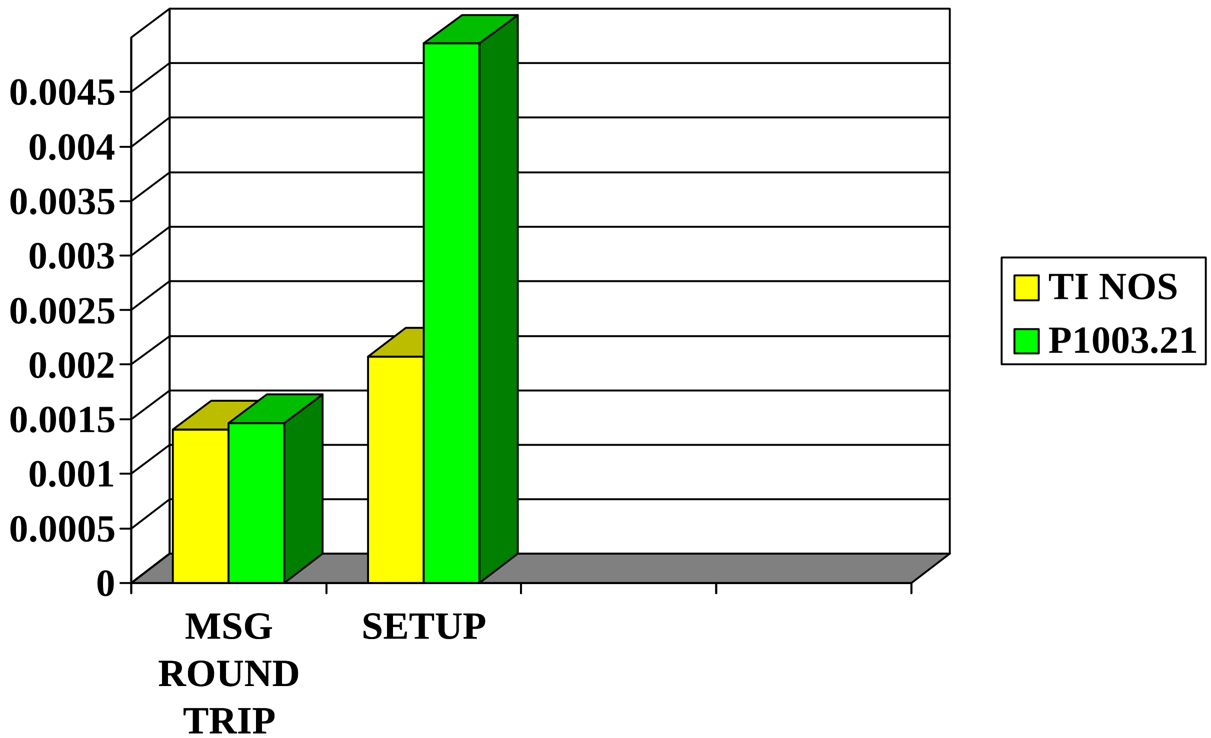


ECPM MAXIMUM I/O AND PROCESSING MEASUREMENTS



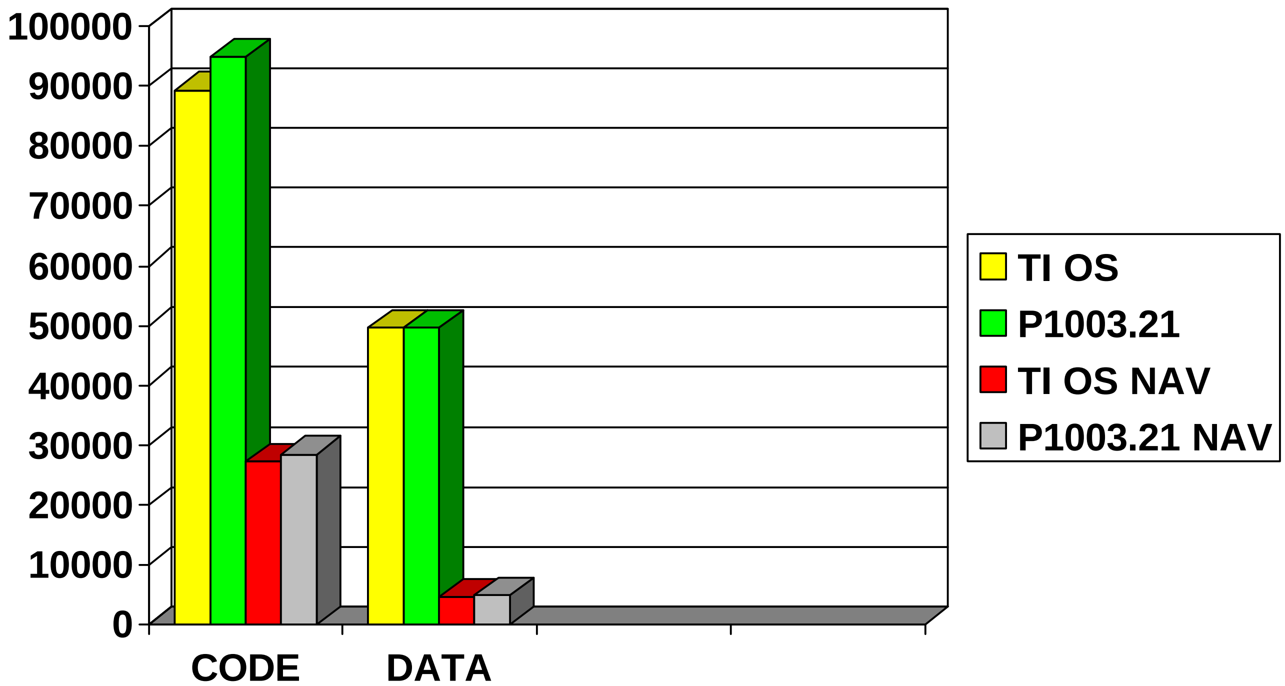
- I/O throughput performance difference between TI NOS and P1003.21 NOS approximately 23.50%
- CPU throughput performance difference between TI NOS and P1003.21 NOS approximately 0.16%

INDIVIDUAL OPERATION TIMING MEASUREMENTS (IN SECONDS)



- Average difference between TI NOS and P1003.21 NOS message round-trip time: 4.76%
- Average difference between TI NOS and P1003.21 NOS setup time: 183%

STATIC MEMORY SIZE (BYTES)



- **Difference between TI NOS and P1003.21 OS code size: 5.26%**
- **Difference between TI NOS and P1003.21 OS data size: 0.28%**
- **Difference between TI NOS and P1003.21 NAV code size: 4.21%**
- **Difference between TI NOS and P1003.21 NAV data size: 3.81%**

Real-time Avionics Profile (RAP) Coverage

	# of POSIX Options used by RAP							%Coverage	
	.1	.1b	.1c	.1d	.1h	.1m	.21		
RAP	7	14	7	5	2	1	1	Stds	All
VxWorks	2	10	0	0	0	0	0	42.9	32.4
LynxOS	7	13	2	0	0	0	0	78.6	59.5
Chorus	1	6	5	0	0	0	0	42.9	32.4
QNX	5	7	5	2	0	0	0	60.7	51.4
Power/UX	7	13	0	0	0	0	0	71.4	54.1
Std?	Yes	Yes	Yes	No	No	No	No		

IEEE STANDARDIZATION PROCESS & STATUS

8/92 Submit PAR

1/93 Approve PAR

3/93 Organize Working Group

Develop Draft Standard

today

Ballot Draft Standard

Approve Draft Standard

Publish Approved Standard

10/96 Completed 1st Ballot

5/98 Scheduled 2nd Ballot

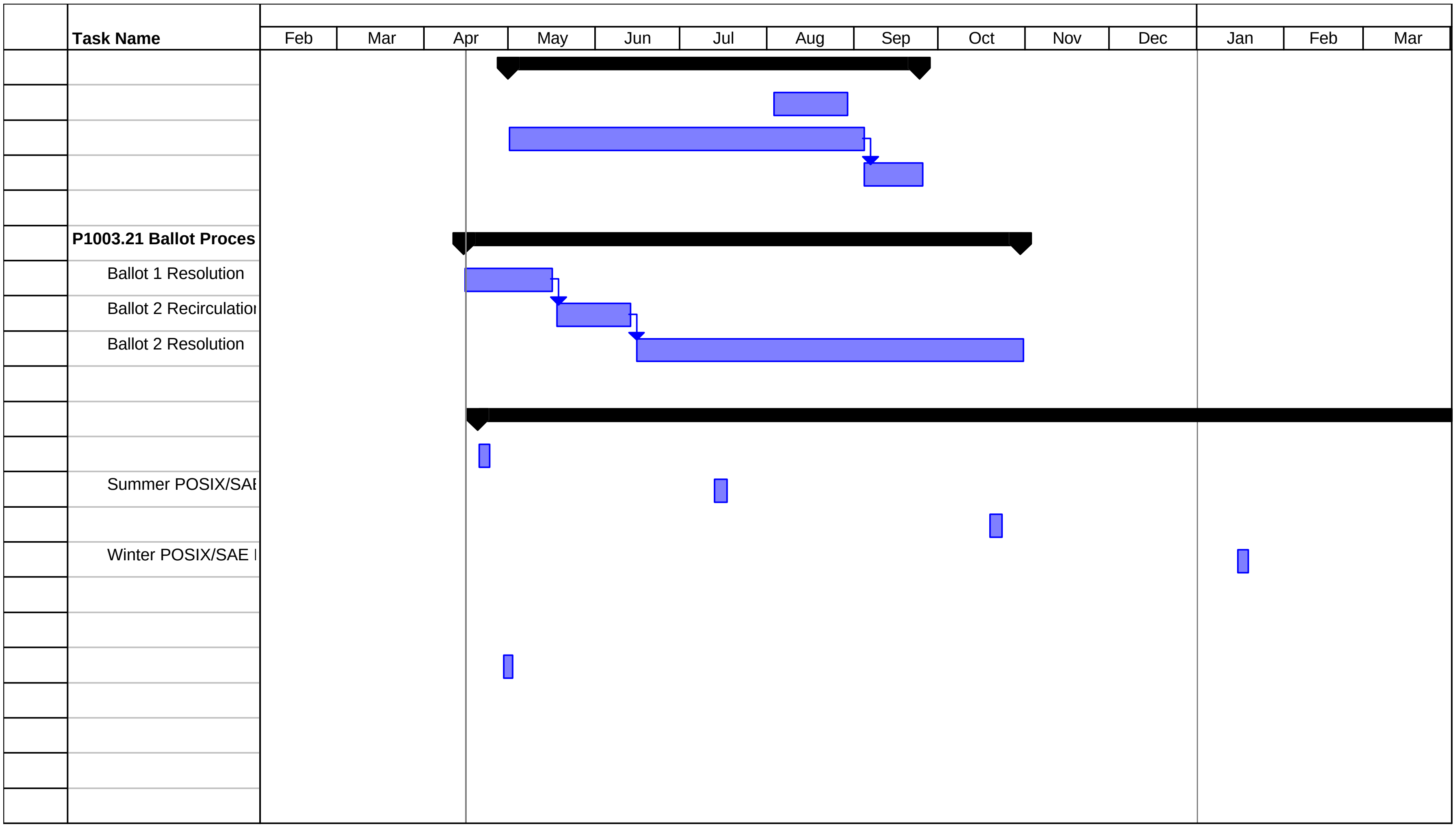
GOAL

International Standardization

CURRENT ORGANIZATIONS REPRESENTED IN P1003.21

- Johns Hopkins University - Applied Physics Lab
- Lockheed-Martin
- MITRE Corporation
- Naval Undersea Warfare Center, Newport
- Raytheon Systems Company
- Software Engineering Institute, Carnegie-Mellon University
- U.S. Army Tank-Automotive Research Development and Engineering Center (TARDEC)

PROJECT SCHEDULE



ISSUES

- Goal is to achieve approval of P1003.21 within 2 years
- Additional vendor support of P1003.21
  - Emerging standards development efforts declining
- P1003.21 is a stand-alone POSIX standard
  - Core POSIX standard is all standards and approved Project Authorization Requests (PARs) in January, 1998
  - C language binding PAR for P1003.21 just approved
    - P1003.21 does have an approved Ada PAR
  - Core standard can be modified by PASC in the future

RECOMMENDATIONS

- Continue standard-based prototypes
  - P1003.21
  - Continue prototype development toward a full RAP implementation
- Explore use of P1003.21 in other domains (e.g. CORBA)
- Continue support for standards activities
  - P1003.21 Ada and C bindings
  - Additional required services (e.g. light-weight directory service agent)
- Additional recommendations to be made at end of project

SUMMARY

- Participants have long history of supporting open systems including POSIX, SAE and OMG
- Standardization of real-time distributed communication interface:
  - Facilitates portability of application software - key to affordability
  - Provides infrastructure for interoperability
- Standardization allows more re-use of application software and stability
- P1003.21 provides flexibility
- Consistent funding and support required to publish international standard

Question & Answer

BACKUPS

CORPORATE & GOVERNMENT INVOLVEMENT (WORKING GROUP MEMBERS PROMOTING STD)

- **CHAIR**
  - **B. Craig Meyer, SEI**
- **VICE-CHAIR**
  - **Shirley Bockstahler-Brandt, JHUAPL**
- **TECHNICAL EDITOR**
  - **John Brennan, NUWC, Newport**
  - **Bill Pollak, SEI**
- **BALLOT COORDINATOR**
  - **TBD**
- **INTERNATIONAL STANDARDS LIAISON**
  - **TBD**

Submit PAR

Approve PAR

Organize Working Group

Develop Draft Standard

Ballot Draft Standard

Approve Draft Standard

Publish Approved Standard

BENEFICIARY POINTS OF CONTACT

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UNDERSTANDING IEEE STANDARDIZATION

Project Authorization Request (PAR)

- Valid for Four Years
- Standard "shall"
- Recommended Practice "should"
- Guide "may"

Types

- New
- Revision
- Supplement

Numbering

- Separate, but related ---1003.#
  - base + number
- Supplements/amendments --- 1003.a
  - base + letter

- **1003.21 RT Distributed Communication**

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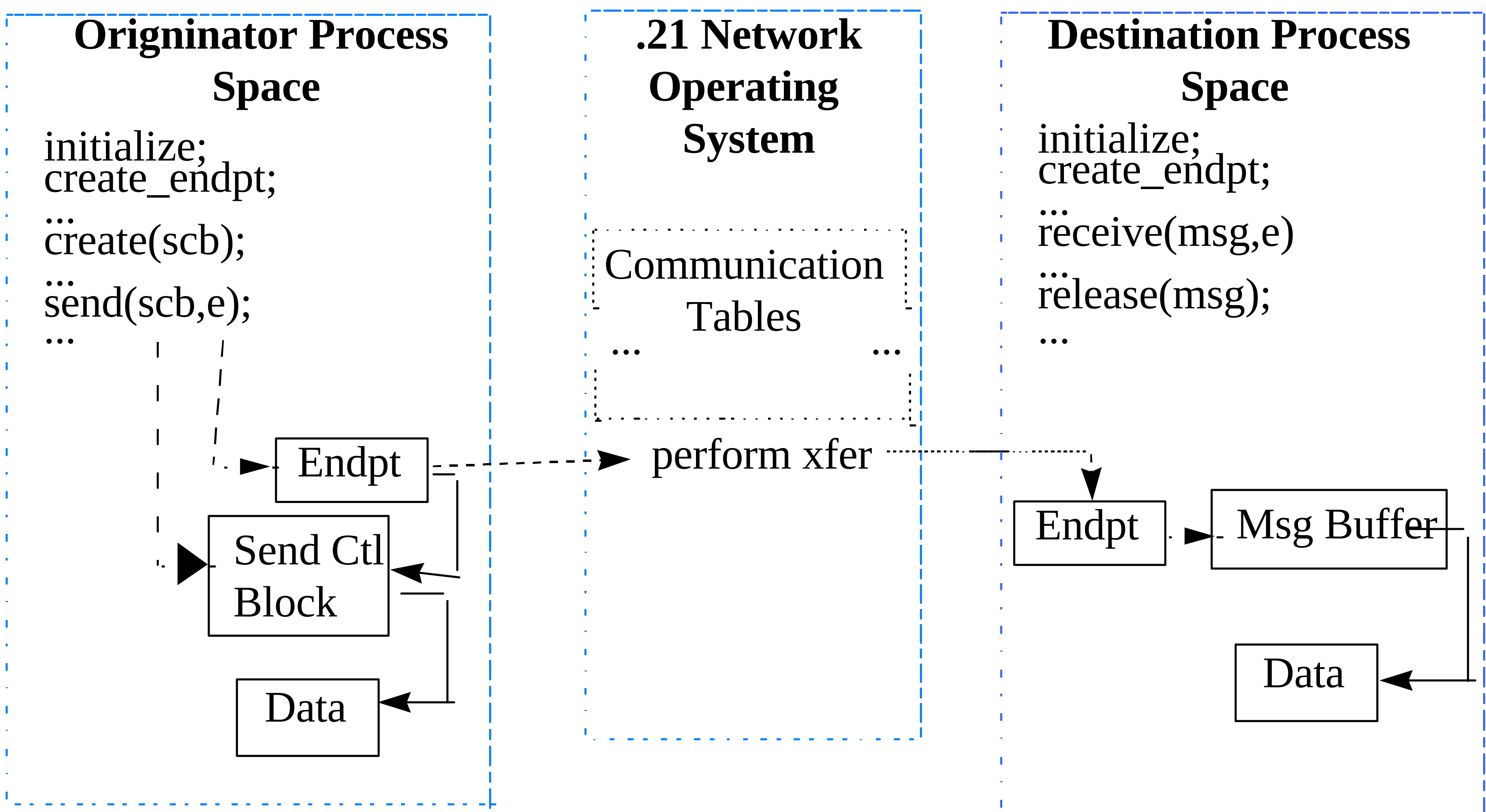
IEEE 1003.21 RTDSC CATEGORIES

- Initialization
- Asynchronous Operations
- Buffer Management
- Endpoint Management
- Directory Services
- General Data Transfer
- Unicast
- Broadcast
- Event Management
- Protocol Management
- Labeled Messages
- Multicast Groups
- Connection Management
- Termination

IEEE 1003.21 RTDSC

- Sending Messages from Endpoint to Endpoint
- Endpoints May be Shared Among Threads in a Process
- Buffer Management allows Application Control of Memory Allocation

P1003.21 MESSAGE TYPES MODEL



P1003.21 PROTOTYPE

- **Objective: Support critical JSF milestones:**
  - **Selection of JSF core processor operating system**
  - **Demonstrate operating system concepts**
- **Approach:**
  - **Prototyped subset of P1003.21 API using TI Reconfigurable Network Operating System (NOS) as the underlying protocol**
  - **Chose subset that (1) performs basic message passing and (2) contains operations analogous to TI NOS operations**
  - **Collected timing and memory size measurements at the system level, as well as for individual operations, for both P1003.21 and TI NOS implementations**

P1003.21 PROTOTYPE, cont.

- **Outputs:**
  - **Measurements to assist in determining POSIX applicability to next generation real-time avionics computing performance requirements**
  - **Measurements will also provide feedback to IEEE P1003.21 working group to fine-tune development of specification**
  - **Recommendations for tailoring P1003.21 for real-time avionics systems**

CONCLUSIONS

- Real-Time avionics systems do not require all procedure calls currently specified in P1003.21
- P1003.21 API does not add a large amount of overhead
- Quality of API implementation is greatest factor in performance and sizing measurements
- Additional experiments recommended
  - Prototype other P1003.21 communication models